NASA RESEARCH GRANT NsG 237-62

Semiannual Report for the Period
ending August 31, 1964

Submitted by: Willard F. Libby

Institute of Geophysics and Planetary Physics
University of California, Los Angeles

August 31, 1964

I N D E X

INTRODUCTION

UCLA has administered a NASA grant in support of space-related research in the physical and biological sciences and engineering for approximately three years. This report covers the activities supported from NASA Research Grant NsG 237-62 for the past six months.

A section of the report is devoted to a summary of the financial details of the grant. It is again emphasized that this section is not an official accounting report which must, of course, be made by the Accounting Office. However, the summary herein given is a very good approximation of the total expenditures, future commitments, and current balance.

PHYSICAL SCIENCES

FUNDAMENTAL PROBLEMS IN ASTRONOMY

L. H. Aller Account No. 448610

Stellar Energy Distributions

Previously I reported that in collaboration with Robert Norton, now at JPL, reductions of the energy distributions in two dozen southern stars had been completed, including Canopus and several others that are of interest as reference points for the guidance of space probes. These data have been submitted for publication in the Astrophysical Journal.

See also: Aller, L. H., Contr. Bosscha Observatory (Bandung, Indonesia) No. 21, 52-57, 1963.

Recombination in a Highly Attenuated Plasma

A gaseous nebula constitutes a more highly attenuated plasma than can be attained in a laboratory; hence, recombination phenomena can be studied under more extreme conditions than are possible experimentally. As reported, J. B. Kaler (NASA trainee) undertook a comparison of the predicted and observed intensities of the recombination lines of hydrogen, helium, and ionized helium, in several gaseous nebulae. He found that the lines arising from higher levels, $n = 20$ to $n = 35$, tend to be stronger than the theory predicts in a number of nebulae, although a few objects show excellent agreement with theory. The deviations do not appear to be correlated with density nor with ambient temperature.

Their interpretation must involve difficult theoretical problems.

The Abundances of Iron and Silicon in the Sun

Measurements of the solar iron-hydrogen and silicon-hydrogen ratios, based on lines of both the ionized and neutral elements, yield an iron-silicon ratio that is in good agreement with that obtained earlier by Goldberg, Müller, and Aller, and which is much smaller than the value found for most meteorites. Recently Schmitt (General Atomics, San Diego) and Goles (UC-San Diego) have found somewhat similar Fe/Si ratios in the chondrules of Type II carbonaceous chondrites. These objects may have a chemical composition closely correlated with that of the sun.

24" TELESCOPE FOR PLANETARY AND STELLAR OBSERVATIONS

L. H. Aller Account No. 448619

Work on the 24-inch telescope described in the last report is proceeding on schedule. We plan to locate the telescope on the grounds of the Thacher School in Ojai until a better site can be found.

SITE SURVEY FOR A LARGE TELESCOPE FOR PLANETARY AND STELLAR STUDIES

L. H. Aller Account No. 448621

A double-beam site-testing telescope has been purchased from Boller and Chivens and is at present in operation in Australia.

Application had been made to the National Science Foundation for funds to undertake a site test in the southern hemisphere for an observatory to be equipped with a large modern telescope. NSF did not feel able to support this undertaking, but fortunately funds were granted by The Regents to enable a site-testing team to carry on a modest program in Australia.

ORGANIC GEOCHEMISTRY

C. Rainer Berger Account No. 448604

This research will be continued when a new supply of thucholite is received.

SOLID STATE PHYSICS

H. E. Bömmel Account No. 448611

Continuing project.

CRYSTAL GROWING LABORATORY

H. E. Bömmel
W. F. Libby

Account No. 448611

Electrical power installation for the muffle furnace, plasma jet and Czrochralski cyrstal puller was completed in June. After this the Czrochralski crystal puller was assembled and tested. This equipment will be used to grow single crystals of silicon and copper. The plasma jet is being assembled by the manufacturers, MHD Research Inc.

A Bridgman furnace was designed and constructed in the laboratory and has been used to grow single crystals of lead, zinc, magnesium and indium. The crystals have been X-rayed in the Engineering Department. Attempts are now being made to grow single cyrstals of lead and magnesium doped with Europium. This requires use of both the Bridgman and muffle furnaces.

The hydrothermal press was used in an attempt to freeze in the high pressure phase of tellurium. This was done by cooling a sample of tellurium, under high pressure, from 550°C to nitrogen temperature. X-ray diffraction patterns were then made of the tellurium, and it was checked for superconductivity. This process is now being tried on a sample of strontium.

EXPERIMENTAL PLASMA PHYSICS PROGRAM

K. R. MacKenzie Account No. 448622

Mr. Thomas Karras has been granted the Ph.D. degree. He observed two distinct modes of RF breakdown which he was able to correlate with the theory developed in his thesis entitled "RF Breakdown in a Nonlinear Electric Field". The material is being prepared for publication.

The thesis of E. Lindman entitled "RF Breakdown in a Linear Electric Field" has been completed. This work was done with pure gases in an ultrahigh vacuum system. In a breakdown mode which depends on collisions with gas atoms, the resonances as predicted by the Mathieu equation were observed, but the RF voltage levels required were (as expected) roughly inversely proportional to the ionization potential of the gas. A deviation in what was previously identified as the resonance mode of breakdown was observed which seems to be strongly surface-dependent. The mechanism has not been identified.

MARINER PROJECT

P. J. Coleman, Jr. Account No. 448615

Introduction

Under this project, a group has been formed which is concerned for the most part with the reduction and analysis of data

obtained from experimental work in magnetic fields and magneto-hydrodynamics. During the reporting period the group consisted of three halftime computer programmers (graduate students in mathematics or physics) and two data readers and keypunch operators (undergraduate students).

Progress During the Period

During this period, the reduction and analysis of data from the magnetometer carried by Mariner II were continued. Tasks which were completed include:

(a) The reduction and analysis of pre-flight data pertaining to the magnetic fields generated at the magnetometer by currents in the spacecraft. The results of this analysis provided sets of constants relating the magnitudes of the DC currents in the various spacecraft circuits to the components of the magnetic fields produced by these currents at the magnetometer sensor. Using these constants, and the telemetered magnitudes of the spacecraft currents, corrections to the magnetic field values measured during the entire flight were calculated.

(b) The analysis of the in-flight-calibration (IFC) data was nearly completed. These data consist of the field changes recorded when the IFC circuit was actuated in flight. Since the IFC field changes are in superposition with the naturally occurring changes in the ambient field, the usual statistical methods were employed to separate the components of the recorded changes contributed by the IFC from other field changes occurring simultaneously.

(c) The reduction of data obtained in an effort to determine the current paths which might have been set up when the Mariner solar panels failed. These measurements resulted from laboratory simulation of possible failure mode current paths using the proof-test model of the Mariner-R.

(d) The production of a computer program to accurately define and classify the periods of the flight for which no magnetometer data are available.

(e) The production of a computer program to establish the intervals of the flight during which the recorded temperature of the magnetometer electronics package aboard Mariner II was varying.

Several of the items discussed above are described in more detail in the report pertaining to work accomplished under NASA grant NsG 249, since these tasks were actually supported by funds from both NsG 237 and NsG 249. The reasons for this joint effort have been discussed previously. However, in the latest renewal for NsG 249, funds were specifically requested for the support of the Mariner Project group working under NsG 237. The requested funds were made available effective July 1, 1964. Accordingly, from that date this group has been supported under NsG 249. Thus, the Mariner Project section of the report on NsG 237 will not appear in future reports on the UCLA Space Program.

MAGNETOHYDRODYNAMICS PROJECT

P. J. Coleman, Jr.
U. Fehr

Account No. 448616

Introduction

The work under this project is intended to yield laboratory facilities which will provide an environment sufficiently low in magnetic noise to permit testing and calibration of relatively sensitive magnetometers. The basic component of these facilities is a magnetically shielded room which is intended to provide a working volume comparatively free from man-made magnetic noise, as well as naturally occurring magnetic noise, normally found in the laboratory.

Progress During the Period

As mentioned in previous reports, the non-magnetic test chamber, intended to provide a wide range of environmental temperatures within the magnetically quiet volume of the shielded room, has been completed by Delta Design, Inc., and delivered to UCLA. Work on modifications of the room which are required for the installation of the test chamber system continued during the period.

One of the more difficult problems encountered in this modification program was one that involved the connection of the temperature chamber within the shielded room to the ducts which carry the hot and cold air from the control equipment to the room. This air must flow through ducts close to the walls

of the room, but the walls themselves must not be allowed to change temperature, since their magnetic characteristics are temperature-dependent. The more conventional techniques of avoiding temperature changes in the walls involving the use of thick insulation were undesirable because it was necessary to minimize the area of the openings in the magnetically shielded walls through which the air was to flow. To solve this problem, a running water system which will maintain the affected area of the walls at constant temperature was designed. The installation will be undertaken by the Building and Grounds Department in the immediate future.

The work pertaining to the testing and modification of the facility proceeded at a somewhat slower pace during this period due to the fact that the facility was in considerable demand for use in testing and evaluating several magnetometers. We are still planning to complete the testing and modification of the shielded room facility by the end of the summer. However, the recent acceptance by NASA of our proposal for the OGO-E spacecraft may lead to a somewhat later completion date, since we hope to develop a rather specialized magnetometer for our OGO-E experiment. This development may involve further demands for operating time in the facility.

ANTENNA PROJECT

P. J. Coleman, Jr.
E. S. Gillespie

Account No. 448617

Introduction

The work under this project is intended to establish the feasibility and desirability of using signals transmitted by spacecraft in deep space to obtain calibrations of earth-based antennas, particularly radio astronomical telescopes.

Progress During the Period

As anticipated in previous reports, the first phase of the work on this project included a theoretical study to establish the important parameters of such a calibration system and their effects upon the accuracy of the required measurements. This phase also included a comparison between the method under study and the methods presently used for such calibrations in order to allow an assessment of their relative merits.

During this period, this theoretical study and comparison, which was undertaken by E. S. Gillespie, was completed. The results of this work will be presented in detail in Mr. Gillespie's report entitled "A Survey of the Methods of Testing Large Antennas." The summary contained in the report reads as follows:

"A literature search has been conducted to establish the state of the art of testing large antennas in an effort to

determine the value of the use of space vehicles as sources of test signals. The last such survey that was published was that of Cumming in 1959. Since then there has been an impressive advance in the use of celestial sources for such measurements. Improved techniques in measurements of gain, radiation pattern, and pointing accuracy have been reported. This improvement has been the result of improved instrumentation in radiometry and from the fact that radar and telemetry workers are now exploiting radio astronomy techniques for antenna calibration.

"As a result of this literature survey, it is felt that the use of spacecraft or satellites cannot be justified at this time because the method would not constitute a substantial improvement over other methods of testing. However, this method might be profitably employed in obtaining other scientific information, such as information concerning atmospheric effects."

Due to this recent improvement in the techniques using celestial sources for such calibrations, the study of the feasibility of using signals transmitted from spacecraft for this purpose has been terminated. Mr. Gillespie's report will be completed in the near future.

ROCKET PROJECT

P. J. Coleman, Jr.
U. Fehr

Account No. 448626

The upper atmosphere may be characterized as a dilute, partially ionized, interacting, chemically reacting, radiating gas mixture, embedded in the magnetic and gravitational fields of the earth. The detailed behavior of this complex medium can be studied by producing artificial perturbations in the medium and obtaining simultaneous measurements of any acoustic and electromagnetic disturbances that are generated by the perturbations. Naturally occurring disturbances will also provide some of the desired information.

In order to provide a systematic study of such disturbances, we intend to perform the following tasks in this project:

(1) The development of techniques for artificially generating infrasonic acoustic waves and extremely low-frequency electromagnetic waves in the ionosphere and above.

(2) The development of techniques for detecting such disturbances both on the ground and in the magnetosphere above the atmosphere.

(3) The development of systems which will permit accurate correlation studies of the signals received simultaneously by the electromagnetic and acoustic detectors, both at the surface and aloft.

(4) The analysis of the effects of the ionosphere and the more distant magnetosphere upon hydromagnetic waves and acoustic waves propagating through them.

During the next six months, we expect to pursue the development of the acoustic detector systems and the magnetometer systems for this project. These systems will include both rocket-borne and ground-based versions to facilitate measurements of effects produced at the boundary of the ionosphere.

SOLAR NEUTRONS AND THE EARTH'S RADIATION BELTS

E. J. Flamm
R. E. Lingenfelter

Account No. 448620

A paper entitled as above was published in Science, 144, pp. 292-294, April 17, 1964.

NEUTRON PRODUCTION IN SOLAR FLARES

E. J. Flamm
R. E. Lingenfelter

Account No. 448620

Calculations are presently being made of the intensity and energy spectrum of neutrons produced in solar flares by accelerated proton interactions with helium. The expected flux of the earth is also being calculated.

PROMINENCE EMISSION LINE POLARIZATION AND OTHER RESEARCH IN ASTRONOMY

C. L. Hyder Account No. 448604

I. Prominence Emission Line Polarization

A. Observations.

A Savart plate polariscope was built and installed at the prime focus of the 16-inch coronagraph at Climax, Colorado late in 1963. Attempts to measure the polarization in prominence Hα emission finally bore fruit on March 16, 1964. Since then, 16 observations of polarization in 10 different prominences have been obtained. The results of these observations have been so gratifying that several observational programs involving measures of polarization in emission from prominences, the corona, the chromosphere, flares, surges, etc. are currently underway. Some, if not all, of these programs will be extended and continued throughout at least one solar cycle.

B. Interpretations.

1. Flare-associated Loops

On the first day that polarization was observed (March 16, 1964), loops formed at the west limb after a small flare. I was able to obtain measures of the polarization in the Hα emission from these loops (C. L. Hyder, 1964a). Simple interpretations

of the results lead to a determination of the field strength in the loops of 45 to 60 gauss. This is the first time that an empirical value has been established for magnetic field strengths in loop prominences. I was able also to determine the direction of the field in the loops. All of the interpretations of the observations are in agreement with observations of photospheric fields in the active region below the loops. The values for the strengths of the fields in the loops are, however, lower than one would expect from qualitative theoretical arguments.

Repeated and more detailed observations will shed much light on the nature of loop prominence and active region phenomena.

2. Quiescent Prominences

The interpretations of prominence emission line polarization observations were given a firm foundation by the research carried out in my dissertation and submitted for publication (J. W. Warwick and C. L. Hyder 1964a, b).

My interpretations of the data obtained earlier this year have led to two preliminary conclusions (C. L. Hyder, 1964b) that are being checked by continuing observations of prominence emission line

polarization. These conclusions are (a) prominences are formed in two ways: (i) bipolar magnetic regions that form and evolve in the usual coherent fashion may give rise to a prominence which divides the regions of opposite magnetic polarity, and (ii) two unipolar magnetic regions, essentially unassociated and of opposite polarity, accidentally drift together and establish conditions that are conducive to prominence formation; and (b) the first of these two classes (i) leads to prominence magnetic fields which are ordered and coherently changing over a solar cycle, while the prominences found in the second configuration (ii) are typified by randomly oriented magnetic fields that exhibit no coherent pattern from one prominence to the next.

The polarization of prominence emission lines is very sensitive to the strength and orientation of the prominence magnetic fields; thus, the prominences of class (i) will lead to a coherent pattern of polarization. We may study these prominences as a group and determine the nature of their general structure, evolution, and associations with other solar features. The prominences of class (ii), however, will lead to no coherent patterns of polarization but will be studied individually.

It is possible that certain types of prominences (e.g. ascending prominences) may be of one class or the other, and we may get some crucial clues about general solar physics from these studies.

References

Hyder, C. L. (1964a), Ap. J. 140 (Letter to the Editor).

Hyder, C. L. (1964b), submitted to Ap. J.

Warwick, J. W. and C. L. Hyder (1964a, b), submitted to Ap.J.

II. Coronal Emission Line Polarization

While at Climax I obtained observations of polarization in the "green coronal line" of FeXIV (λ5303) which indicated that the results of R. W. Wood (1905) were correct and that the results of the Russian group headed by Mogilevskii (1960) were in error.

I did the first theoretical research (C. L. Hyder, 1964c) to establish upper limits for the polarization in several coronal emission lines. In general, the results of Mogilevskii, et al. are impossibly high. I found that the "red coronal line" of Fe X (λ6374) cannot be polarized, while the Russians found polarizations ranging from 50% to 80% in this line. Their results for the "green line" at the solar equator lie right at the upper limit which I determined theoretically with highly contrived conditions in the corona.

While the equatorial results for the green line are possible, I do not consider them likely to be correct. They also report observations of impossibly high degrees of polarization for the "green line" near the sun's north pole. For these reasons, I feel that the Russian observations should be discounted.

Verbal approval of a proposal to the AF Cambridge Research Laboratories has been received to conduct observations of polarization in coronal lines during the May 30, 1965 eclipse. Interpretations of the eclipse data will lead to determinations of cross sections for collisional excitation of coronal lines, coronal magnetic field configurations, and magnitudes and directions of electron streaming in the corona.

References

Hyder, C. L. (1964c), Ap. J. (in press).

Mogilevskii, E. et al.(1960), Sov. Astron., 4, 225.

Wood, R. W. (1905), Pub. U. S. Naval Obsy., 4, D116.

III. RANDOM MICROSCOPIC MAGNETIC FIELDS IN A PLASMA

In collaboration with J. W. Warwick (1964c) I conducted a theoretical research to determine the random fields that exist at an atom due to the randomly passing charges in a plasma. We found that in stellar photospheres the uniform field would need to exceed 5 or 10 gauss before there would be clear ordered

field effects as far as linear polarization measurements were concerned. These results are crucial to efforts to determine the transverse component of the general solar field from measurements of linear polarization in fraunhofer lines in the solar spectrum. In order for the simple interpretations that are being used to be valid, the transverse component of the general solar field must exceed 8 gauss.

The same results are applicable to measures of polarization in lab plasmas, i.e. the imposed uniform fields must exceed a few hundred gauss before the effects of the random microscopic plasma fields may be neglected in the interpretations of polarization observations in these plasmas.

References

Hyder, C. L. and J. W. Warwick (1964c), submitted to Ap. J.

IV. The Polar Crown of Filaments and the Sun's Polar Magnetic Fields

A study of the latitude of polar filaments and the sun's polar fields (C. L. Hyder, 1964d) shows that the polar fields reversed polarity just when the polar crowns of filaments rushed to the poles during the last sunspot maximum.

The unique feature of this event is that the fields reversed polarity at the two poles 18 months apart. The reversals occurred in mid-1957 at the south pole and in late 1958 at the north pole. Thus the implied and vaguely understood relationship between the polar crown of filaments and the polar fields has been given a firm observational footing. We may now hope to learn the nature of the relationship from studies of prominences, filaments, and polar fields in detail over the solar cycle.

References

Hyder, C. L., (1964d), submitted to Ap. J.

Further research will be conducted under Account Number 448627.

DISSIPATION OF TIDAL ENERGY

W. M. Kaula Account No. 448604

A study was completed on the dissipation of tidal energy by solid friction in the moon and the earth's mantle, and on the resulting evolution of the moon's orbit. Assuming a constant dissipation factor 1/Q, this effect was found to be most significant at the bottom of the mantle near the pole, where a result of 2×10^{-6} ergs $cm^{-3}sec^{-1}$ was obtained: enough to be an appreciable source of heat for plausible values of Q. Near the surface, the result was only

$.02 \times 10^{-6}/Q$ ergs $cm^{-3}sec^{-1}$, while in the moon tidal friction was an even more negligible source of heat. A theory of orbital evolution was developed in which the disturbing function was expressed in a Fourier series with respect to time, so that the effects of variation of the dissipation factor or lag angle with amplitude and frequency could be examined.

ANALYSIS OF EARTH SATELLITE ORBITS

W. M. Kaula Account No. 448604

This analysis was continued for the purpose of determining variations in the earth's gravitational field. The work was carried on in cooperation with NASA Goddard Space Flight Center. The most significant new results were obtained using the 24-hour orbit of Syncom II which experience a resonance with certain spherical harmonics of the gravitational field. The sensitivity of this orbit is such that it proves determination of not only the equatorial ellipticity, but also some higher harmonics, especially J_{33}. Other work using near satellites has concentrated on combining Doppler with camera tracking, in order to obtain better conditioning, and has progressed slowly because of computer problems.

A general procedure was developed for numerical integration of orbits designed to combine efficiency and

adaptability to different problems. Principal features are the use of equations of motion in terms of Keplerian elements and the averaging of the disturbing function. Problems to which the program has been applied are the evolution of the moon's orbit due to tidal friction; the lifetimes of moon satellite orbits; and radiation pressure and drag effects on earth satellites. An error propagation theory of close satellite orbits was developed, primarily for the more accurate determination of geodetic and geophysical parameters.

Professor Kaula has completed a textbook "Theory of Satellite Geodesy" and submitted it for publication to Blaisdell Division of Ginn & Company.

TRITIUM STUDIES

W. F. Libby
L. L. Wood
J. Leventhal

Account No. 448604

Analysis of glacial ice samples from Mount Everest is nearly completed. Our main problem of contamination by the high levels of tritium in laboratory air is still with us, but every precaution is being taken.

RADIOCHEMICAL STUDIES

R. H. Ide
W. F. Libby

Account No. 448604

The results of this research formed the topic of Dr. Ide's thesis, of which the Abstract follows.

The Production of Tritium and Helium-3 by Proton Bombardment of Metals: Solar Origin of Terrestrial Tritium

Abstract

Radiochemical analyses of recovered satellites have generated considerable interest in nuclear reactions initiated by relatively low energy (< 150 Mev) solar protons. Of particular interest are the results obtained for the Discoverer XVII satellite, which was in orbit during the intense solar flare of November 12, 1960. The amounts of tritium and helium-3 found in portions of the recovered satellite appear to be one and two orders of magnitude too large respectively to be explained as products of reactions induced by solar protons. The fact that the helium-3 content was roughly ten times that of tritium is especially interesting, since proton-induced nuclear reactions were expected to produce roughly equal amounts of these two isotopes.

The expected yields of proton reactions were based mainly on results of work done with protons of fairly high energy (≥ 150 Mev), whereas the majority of the solar protons striking Discoverer XVII had energies below 100 Mev. Very little information is available on production of helium-3 in proton reactions.

In order to help explain the results of the analyses of Discoverer XVII, Professor Libby and I felt that measurements of the cross sections for the production of tritium and helium-3, and especially of the ratio of these cross sections, should be carried out for proton energies in the vicinity of 30-50 Mev.

Accordingly, targets of aluminum and iron were bombarded with 30-45 Mev protons. Each target was then split, and the relative gross gamma activity of the two portions was determined. One portion of each target, together with blanks of the target materials, was then exposed to a thermal neutron flux of about 5×10^{19} n/cm^2.

The tritium content of all the samples was determined by a system of vacuum extraction and gas counting.

The tritium in the target portions which had been irradiated with neutrons arose from three sources: proton-induced reactions, neutron irradiation of target material impurities, and neutron irradiation of helium-3. The amount of tritium expected from the first two sources could be evaluated on the basis of the tritium content of the unirradiated portions of the targets and of the irradiated target material blanks. The additional amounts of tritium in the irradiated target portions were due to neutron irradiation of helium-3 and could be used to calculate the amount of helium-3 produced in the targets by proton bombardment.

The results of this work indicate that the ratio $\sigma_{He^3}/\sigma_{H^3}$ for bombardment of both aluminum and iron with 35-50 Mev protons lies in the range 0.8 - 1.5. The results conclusively show that the tritium and helium-3 in Discoverer XVII were not produced by solar protons.

SOLAR RADIOACTIVITY

L. L. Wood
W. F. Libby

Account No. 448624

Continuing project.

ULTRAVIOLET INVESTIGATION

Carl Jensen
W. F. Libby

Account No. 448624

With the development of the high density plasma source of extreme ultraviolet energy reported previously, we have proceeded with irradiation experiments on chemical systems.

Since methane irradiation experiments are of extremely great interest in the studies of both planetary atmospheres, Jovian type, and of fundamental processes in radiation chemistry, systems containing methane have been chosen for the bulk of the initial studies.

Preliminary experiments on such systems are in process. Results so far are more than ordinarily encouraging, both from a theoretical and from a practical point of view. Methane in quite diffuse concentrations (in microns) has

been converted with considerable efficiency to hydrocarbons of higher molecular weight. This has occurred in both pure methane systems and in systems similar to proposed Jovian atmospheres.

Thus we arrive at the extremely interesting conclusion that methane on Jupiter possibly is being converted with considerable efficiency to long chain hydrocarbons. In a sense then, the solar extreme ultraviolet flux is responsible for a continuous "hydrocarbon rain" on Jupiter. Experiments are underway to correlate this with the recently observed increase in temperature of Jupiter's atmosphere when in the shadow of a moon (B. C. Murray et al., Ap. J. 139, 986,1964).

Further work is proceeding along these lines, as well as application of this work to radiation chemistry, where it is anticipated that this work will supply important information concerning the basic chemistry involved.

HIGH POWER PLASMA GENERATOR

C. A. Jensen
L. L. Wood
W. F. Libby

Account No. 448624

Construction has recently been completed of a very high-power inductively-coupled plasma generating device. Testing is now underway.

The power supply for this device is capable of delivering greater than 500 kw continuous radiofrequency power over a broad continuously variable band. In addition, pulse capabilities of the unit permit operation to 10 megawatts. The power supply is contained in an unusually maneuverable and unprecedentedly small volume, as a result of extensive application of the latest developments in the state of the art.

This power is currently being used in the creation of large volume, very high temperature plasmas by inductive coupling between the supply and the plasma. Maximum power operation under the proper conditions has not yet been achieved so that maximum temperature capabilities are unknown, but straightforward extrapolation from previously obtained results indicates that temperatures of several hundred thousand degrees Kelvin should be easily obtainable while operating with gases at atmospheric pressure. High temperatures can, of course, be obtained by operation at reduced pressures and the instrument has been built with the capability of operating at pressures considerably below one micron.

One important feature of the system is the absence of direct contact between the plasma and any solid body. For this reason there is no limitation imposed on operation at high temperatures due to materials problems. The maximum attainable temperatures are therefore limited by the general physical characteristics of the plasma itself, thus providing

the proper medium for study of such systems. At the same time, the absence of a material container simplifies impurity problems.

As part of our research program with this apparatus we propose to investigate generalizations of the type of experiments performed recently by Babykin et al.[1] and others concerning the creation and containment of very high temperature plasmas. Our apparatus, however, will permit continuous operation at power levels, field strengths, and thus temperatures achieved by previous workers only during transients of a few tens of microseconds duration. It is anticipated that temperatures in the multimillion degree range will be attained in continuous plasmas at appreciable densities, and that information of considerable interest, both theoretically and practically, will be gained.

We have engaged in a program to determine the oscillator strengths (f-values) of several elements of great astrophysical interest with Professor Lawrence Aller and his group in the Astronomy Department; the present values are unacceptably uncertain and it is hoped that the current studies will permit the construction of significantly more reliable models of stellar atmospheres. The advantages of the present approach include separation of the element studied from contact with other parts of the system and the reliable attainment of much higher temperatures than were previously available. Possible

disadvantages include the difficulty of firmly establishing the existence of local thermodynamic equilibrium and the problem of determining precisely the plasma density so as to obtain absolute oscillator strengths; but these will be considerably less severe than in previous approaches to the problem and will undoubtedly yield to the same methods of solution that have been employed in the past.

Another program to study in depth the properties of large strain-free crystals of refractory materials has been launched in conjunction with Professor Hans Bŭmmel's group in the Physics Department, under the auspices of the Crystal Growing Laboratory. The plasma generation unit has the capability of heating relatively large amount of solid or liquid material injected into the pre-ionization region to any desired temperature by radiation and conduction, and this capability will be employed to grow and, simultaneously, anneal crystals of refractory materials of both theoretical and engineering interest in a manner considerably superior to most methods hitherto utilized.

The high vacuum capability of the unit, combined with the high voltage operation of the main oscillator and a very high Q of the oscillator tank, have been used to obtain rf voltages as high as 50 kv per turn of the plate tank coil, and it is anticipated that this will be increased severalfold in the near future. Such voltage and associated current

capabilities, as well as being extremely useful in high power coupling to plasmas, as mentioned above, offer the possibility of creating very high voltage rf transformers and thus particle accelerators in unusually small volumes. We are currently constructing a 50 Mev electron accelerator along these lines to be employed as the active-unit in an extreme ultraviolet-synchroton radiation source, employing magnetic bremsstrahlung in the manner discussed by Schwinger[2] and others; radiation strongly peaked about a readily calculated value can be obtained at a power level of tens of kilowatts in this fashion, with the peak readily shifted from a few tens of Ångstroms to about 1000 Ångstroms by appropriate variation of the accelerating voltage and magnetic field strength. This device will thus produce very large quantities of radiation in a poorly investigated portion of the spectrum whose great significance in astrophysics in general, and space exploration in particular, has become more and more apparent recently. This device is, of course, not limited to the acceleration of electrons.

Other projects in these fields are in the design stage and will be discussed in future reports.

References

1 Babykin, M. V. et al., "Trapping and Containment of a Turbulently Heated Plasma in a Mirror System," Sov. Phys. JETP 16, No. 4, 1092, 1963.

2 Schwinger, J., "On the Classical Radiation of Accelerated Electrons," Phys. Rev. 75, 1912, 1949.

ANALYSES OF CARBON COMPOUNDS IN CARBONACEOUS CHONDRITES

W. F. Libby Account No. 448629

A group to assist in the analyses of carbonaceous chondrites was organized in February with the notice published in Science in April. Support has been given by NASA (Dr. Freeman Quimby) for special efforts to analyze the organic fraction. The UCLA work has been largely restricted to an elementary analysis with standard methods of the neutron activation. These results check the literature values very well and indicate that our sample of Murray, which is the particular meteorite given us by Dr. Henderson, is authentic. Dr. Biemann of M.I.T. and Dr. Lipsky of Yale are now engaged in an analysis of the organic fraction. It has been asked whether an additional analytical group is needed in view of the number of people already interested in the analyses of carbonaceous chondrites. We considered it was essential because the importance of the data and value of the material are both so great.

Members of the group include:

Klaus Biemann, M.I.T.
Samuel Epstein, C.I.T.
E. P. Henderson, U.S. National Museum
E. C. Horning, Baylor University
S. R. Lipsky, Yale University
Gregg Mamikunian, J.P.L.
Brian Mason, American Museum of Natural History
W. G. Meinschein, Esso Research and Engineering Co.
John Oro, University of Houston
W. F. Libby, Chairman, UCLA

BIOLOGICAL SCIENCES

THE EFFECT OF ROCKET EXHAUST GASES ON THE COMPOSITION OF THE FLORA AND FAUNA IN THE INTERTIDAL ZONE

R. A. Boolootian Account No. 448674

Location of rocket launching sites at or near the ocean shore may pose a problem of concern to both the military and the civilian population. Since rocket exhausts are known to produce a number of toxic products dependent upon the fuel used, there exists the possibility of contamination of the ocean life, primarily that encountered in the intertidal zone. Contamination of this intertidal zone is of importance since modification of the marine life at this point may well cause reflections in the populations of ocean life in other areas.

The purpose of this proposed program is twofold:

(1) To determine at some convenient location, such as at Point Arguello, whether there has been contamination of the intertidal zone and to what extent this contamination is of a serious nature.

(2) To determine the physiological responses of intertidal animals to the common toxic products encountered in rocket exhaust with an eye toward defining permissible concentrations of toxic products, responses to these products, and ways of controlling or eliminating undesirable concentrations of toxic materials.

Method of Investigation

The methods that will be used under this program are two-fold in nature, and to a large measure may be carried on simultaneously.

(1) A survey of intertidal animals will be conducted at Point Arguello over a period of two years. This survey will be compared to a similar one carried out simultaneously at a location that would afford a comparable environment except for the possible rocket exhaust contaminates.

(2) Animals from both Point Arguello and the control area will be examined to determine respiration characteristics, general state of health and reproductive capacity. Animals from both areas will be used to determine "killing curves" for the principal contaminant found in the Point Arguello area. Animals from both areas will be maintained in the presence of known concentrations of toxic material and the reversibility of any destructive responses will be studied.

PATTERN RECOGNITION OF SENSORY SIGNALS IN ANIMALS

T. H. Bullock Account No. 448675

The purpose of this research is to investigate in particularly favorable animals, including marine mammals and fish, how complex signals received by the sense organs, such as sounds and sights, are processed by the brain in order to achieve recognition, and to analyze the relevant events

at the level of unit nerve cells at different points along the afferent pathway. The present support will permit a concentrated attack by adding one electrophysiological station to the present complement. With the program underway, it is expected that outside support for continuance will be attracted.

The general program of matching signals, in the presence of noise, against some predetermined criteria (recognition) is basic in communciation science. It is solved in the brain of animals in a more elegant degree than is yet understood. But recent developments have driven deep wedges into the difficult neurophysiological problem of exposing the mechanisms employed in the brain.[1,2] Research has begun with efforts to analyze nerve cells in the visual pathway that responds only to rather complex events in the visual environment, and a preliminary paper has been published in Science. We are beginning to do the same for central units integrating from the peripheral electroreceptors in electric fish, together with two visiting postdoctoral investigators, Drs. P. S. Enger of Norway and T. Szabo of France.

We are anxious to exploit the special advantages of the auditory system. Here the physical attributes of the signal

---

1. Grinnel, A. D., three papers on central neurophysiology of hearing in bats, J. Physiol., June 1963.

2. Maturana, H. R., J. Y. Lettvin, W. S. McCulloch, and W. H. Pitts, J. Gen. Physiol., 43, (6, Suppl.), 129-175, on complex recognition units in the frog visual systems.

are easy to define and control; animals achieve remarkable feats of recognition, and a good deal is known about the peripheral receptive mechanism and its filters.

The present proposal contemplates bringing the leading worker on central neurophysiology of bats, Dr. Alan Grinnell of Harvard, and a second technically excellent worker on hearing in insects and mammals, Dr. T. Suga of Tokyo, to the UCLA campus. It is planned to set up experiments in two aspects of the problem, one in the Los Angeles laboratories, and one in the La Jolla laboratories of the Brain Research Institute.

THE BIOLOGICAL CLOCK IN RELATION TO SEED GERMINATION, FLOWERING IN PHARBITIS AND INSECT METAMORPHOSIS

K. C. Hamner
M. W. Coulter
T. Hoshizaki
A. Takimoto

Account No. 448670

Studies on the nature of the biological clock have continued with investigations of photoperiodic flowering responses, photoperiodic sensitivity of seed for germination, and the periodicity of leaf movements in plants. We have proposed that studies of periodic endogenous rhythms, and particularly those under photoperiodic control, would help reveal the mechanism of biological time measurement.

Studies of the photoperiodic responses of Pharbitis nil (Japanese morning glory) and Glycine max (Biloxi soybean) by

Drs. Takimoto and Coulter, respectively, have shown that the biological clock, or timing mechanism of each, has three separate and distinct components. Two of the components are rhythmic processes and may be phased, or perhaps initiated by "light on" and "light off" signals. The third component appears to operate like an interval timer and may be associated with a critical dark requirement. Dr. Coulter has also conducted investigations with Xanthium which indicate a pulsation response to light perturbations similar to one of the components exhibited by Pharbitis. In light of the information provided by Pharbitis, the photoperiodic response of Xanthium will be completely reinvestigated in order to determine if other timing components are present.

Screening studies on seed germination by Drs. Coulter and Hoshizaki have thus far revealed no evidence of endogenous rhythms which might be related to a biological clock. Investigations of hour-glass time measurements, however, have been pursued and particularly with respect to photoperiodic inhibition of seed germination in Phacelia. Determination of the action spectrum of this dormancy phenomenon is now being completed by Dr. Coulter. Extreme accuracy in this determination has been made possible by the development of a spectroradiometer under a grant to Dr. Hamner by the National Science Foundation. The spectroradiometer will analyze light and record actual energy for the various wave lengths of the visible spectrum. This facility has allowed accurate analysis

of various light sources and filter systems used with our biological material.

Facilities for electronic metering of leaf movement responses have now been completed, and Dr. Hoshizaki will continue to accumulate leaf movement data for computer analysis of the endogenous rhythm associated with it. Efforts will be made to determine if the biological clock associated with leaf movement is the same or different from that which mediates the photoperiodic flowering response in Biloxi soybean. By the application of alternate light and dark treatments, attempts will be made to determine if there are separate timing components associated with the initiation and extinction of light.

MARINE BIOLOGY

K. S. Norris
R. N. Turner

Account No. 448672

A study is being made of the echo-location capacities of porpoises and of the operant conditioning of these animals. There are several aspects of this program of considerable importance to problems of space biology. First, and perhaps of greatest importance, concerns the establishment of low error level performance in animals operating under operant conditioning controls. For animals that have been used in space programs in the past, an accurate biological communication system has been absent to a considerable extent. For

example, in the space shots involving chimpanzees, error levels were surprisingly high. Work with marine animals has shown that this level can be reduced to a small fraction of that found in these previous space efforts. Much more precise communication is possible using non-human subjects than has been found in the past. Marine mammals have not been considered for this sort of work in the past, perhaps because it is felt that they must be maintained in a fluid medium. This is not true, however, for all of them can be handled out of water for long periods. Their lives in the essentially dimensionless world of water make them especially valuable for certain space problems. For example, the bodily orientation of marine mammals is of relatively little importance to them. They may operate in any position relative to the earth, and it is felt that this capacity may have application to space problems not found in other mammals. Another particularly valuable aspect of work with these animals is their obviously high mental capacity and brain size. It is reasonable to expect very high and complicated performance from them of a quality not found in most infra-human subjects.

Another aspect of the biology of marine mammals that may prove valuable in space science is the unusual sleep patterns found in some of them, in which the animal remains essentially alert over the entire 24-hour period with very

brief moments of sleep interspersed. Very little is known about the basis of this patterning. Finally, present work concerns shaping vocal behavior in these animals. It is felt that this method of communication could be especially valuable for the operation of voice-operated relays and telemetering systems, if it can be made precise enough. There is every indication that these large brain mammals are capable of great refinement of their vocal system. It is felt that a large number of discriminations may be communicated by such shaped voice signals, in conjunction with the low error levels now being investigated.

GIBBERELLINS FROM *ESCHERICHIA COLI*

B. O. Phinney
C. Spector
D. R. Robinson

Account No. 448673

Purpose

The specific objectives of this research are twofold:

1. To confirm and extend unpublished evidence recently obtained from this laboratory for the presence of gibberellins in the bacterium, *Escherichia coli*. This new and unique information will lead to a publication within the year (1964).
2. To irradiate *Escherichia coli* with U-V light and screen for gibberellin-requiring mutants. This

aspect is an exploratory study that is a logical consequence of the discovery of native gibberellins in Escherichia coli.

Gibberellins are a class of plant hormones which originate biosynthetically from the diterpenes. They are structurally related to the steriods, and they are naturally-occuring in most plant products eaten by man. While little is known on the relation of gibberellins to animal nutrition, they are a component of all vegetables and fruit eaten by man, and it is quite possible that they may be essential for a balanced diet, and thus important in nutritional requirements for space travel. It is known that gibberellins are essential for many types of normal growth in plants. For instance, the absence of gibberellins in maize results in dwarfism, and the ability to respond to gibberellins is under genetical control. Gibberellins should be one of the factors considered in the growth of plants in space. The demonstration of gibberellins in the bacterium Escherichia coli will greatly facilitate studies on the metabolism of gibberellins, i.e. where they come from, what happens to them, what is their mechanism of action. This microorganism would also be useful in the study of effects of radiation on biological systems concerned with gibberellins and growth.

Gibberellins are a class of compounds which markedly increase the number and size of cells in plants. The net

effect is to increase the size of the plant. These compounds are also known to initiate seed germination, and to replace the light requirement and cold requirement for the flowering of certain types of long day plants. The first demonstration of the natural occurrence of gibberellins from flowering plants came from our laboratory; we were also instrumental in the first isolation and chemical characterization of a gibberellin from flowering plants.

Detailed Research Program

Escherichia coli, K-12 strain, will be grown as shake cultures (250 ml. erlenmeyers) for a period of 72 hours at 28°C; innoculation will be from a rapidly growing culture using a 1 ml. innoculum with a cell density of 10^6 cells/ml.

Cells are harvested at zero degrees centigrade, centrifuged, and the pellet recovered and immersed in 95% acetone. Three consecutive extractions are made with acetone over a period of two days. The acetone (100 ml.) is removed by flash-evaporation, the precipitate resuspended in water, and the water solution adjusted to a pH of 3. Six extractions are carried out between water-ethyl acetate at alternating pH's of 3 and 8. The final ethyl acetate fraction is saved and spotted on filter paper, chromatogrammed in a butanol-acetic acid solvent system, and the active fraction eluted with acetone. The active fraction is then assayed on dwarf maize by standard methods. Following confirmation

of biological activity, the active fraction will be further purified by silicic acid chromatography and additional biological and chemical properties determined.

In an attempt to find mutants of Escherichia coli which require gibberellins for their growth, the Lederberg replica plating technique as modified by Gorini will be employed. This technique has been used in this laboratory and amino acid mutants obtained at a frequency reported in the literature. Purified gibberellin preparations will be substituted for the amino acid supplement and colonies selected for their inability to grow on minimal media and the ability to grow on gibberellin-supplemented media.

ENGINEERING

EFFECTS OF PROTON BOMBARDMENT ON MATERIALS FOR SHIELDING AGAINST SOLAR FLARES

J. P. Frankel
M. Appel

Account No. 448634

In the previous report, details were given concerning the heavy deuteron bombardment of an ultrapure aluminum disk and its subsequent appearance. Gaping cracks were discovered in the interior of the aluminum at a distance from the surface upon which the beam impinged equivalent to the calculated range of the deuterons. Smaller voids

surrounded the cracks. Microhardness measurements were made on the cut edge near the cracks and also far from the irradiated region. These measurements show that a substantial increase in hardness resulted from the irradiation. It is believed that this increase is not attributable to the ordinary mechanisms of radiation hardening, but may be due to solid solution hardening.

A total of five X-ray diffraction studies have been made. Two were made of the back of the deuteron-irradiated disk; one was made of the cut edge of said disk; one was made of the front of the disk, and one was made of the proton-bombarded specimen. The five diffraction studies yielded 20 peaks which were unaccounted for by the face-centered cubic structure of aluminum. Of the 20, four were duplicates, and of the 16 unduplicated peaks, 13 were found to belong to a hexagonal close-packed structure through the use of a Hull-Davy chart. The lattice parameters of the new structure have been determined.

There is very good correlation between the d-spacings obtained in these studies and those stated in the literature for unsolvated aluminum hydride prepared by wet chemical means.

It has further been determined that surface effects are not responsible for these new peaks. There are no compounds listed in the ASTM Index which possess any combination of

these thirteen new peaks as their principal peaks.

This research will be continued in the fall of 1964.

GENERAL INSTABILITY OF STRUCTURES

W. C. Hurty
J. N. Habib

Account No. 448636

The following is the abstract of Dr. Habib's Ph.D. dissertation:

Abstract

The matrix force and displacement methods have been widely accepted as most attractive and most powerful tools for the analysis of complex redundant structures. These are approximate discrete methods and the first step in applying them to any structural problem is to discretize the structure. The structure is, hence, idealized into an interconnected net of structural elements whose independent behavior can be represented by simple expressions. These expressions are then combined, with due regard to certain boundary conditions, to furnish the complete solution to the problem. Matrix algebra, used throughout, renders the whole process rather compact and elegant.

Within some ten years of development, the linear matrix methods have reached a high degree of sophistication by continuous improvements in the idealization techniques. In this study, the matrix methods are extended to cover the nonlinear

problems of instability and large deflections. An elementary idealization scheme with simple geometries is used so that the fine points related to instability problems will not be overshadowed by unnecessary complexities.

The instability problem is shown to be a special case of the large displacement analysis. When large displacements are involved, the equilibrium of the deformed structure should be referred to an Eulerian frame of reference. This is a complex procedure and renders the resulting equations highly nonlinear. As an alternative approach, the Lagrangian frame of reference is retained but certain corrections are introduced as perturbations to the linear solution.

The geometric nonlinearities associated with large displacements introduce two types of interactions. The first is a first degree function in the displacements and represents the interaction between internal stresses and the displacements, while the second is a second degree function in the displacements and represents their interaction with the internal strains. These interactions are derived here, in matrix form, based on the linear analysis results.

The force-displacement coupling is introduced into the analysis as equivalent fictitious forces in both the force and displacement methods. The strain-displacement coupling is introduced as fictitious strains in the force method and

is, hence, treated simply as initial strains. In the displacement method, it is introduced to the elemental stiffness matrix of the plate element and results with an incremental stiffness matrix. This should be added to the linear elemental stiffness matrix to obtain what may be called an instantaneous stiffness matrix.

When both types of coupling are taken into consideration, the analysis results, in both the force and displacement methods, with nonlinear equations which can only be solved by iteration. The iteration process is discussed and presented in detail. The strain-displacement coupling, being a second order effect compared with the force-displacement coupling, can be neglected when the displacements are not too large. In such a case, the equations can be solved directly for the displacements. In fact, they result with an eigenvalue equation which is the linearized instability criterion of the standard buckling problem associated with small displacements.

ULTIMATE STRENGTH AND STRESS FIELD OF PLATES AND SHELLS UNDER LATERAL PRESSURE AND EDGE COMPRESSION

T. H. Lin
J. E. Taylor

Account No. 448633

Circular plates under combined lateral loads and edge compressions with nonlinear strain hardening creep have been analyzed for different edge conditions by treating the inelastic strain as equivalent forces. The same technique works

equally well for circular plates loaded into plastic range. Numerical results show clearly how the plates behave under loading. It is believed that by using this approach, rather than the present limit analysis or interaction curve method, a more realistic optimum design can be made.

A simply supported circular plate loaded into plastic range under both lateral loads and edge compressions is analyzed. The numerical result shows the propagation of the plastic region as well as the stress and strain fields.

The same method can obviously be extended to plates with finite deformation. Formulation is under way by applying the variational principal.

FUEL CELL AND CORROSION RESEARCH

K. Nobe Account No. 448631

The most recent experiments have shown that the differential capacitance shows a linear time dependence after about fifteen hours. Pulses from between 5 to 20 times the magnitude of the corrosion current show that this effect is real and not merely an error in the experimental technique, i.e. using too small a value of pulse current.

Comparison of the polarization caused by a constant current decreases with increasing value of the capacitance. The data available at this time suggests a linear dependence,

but, when the present series of experiments is completed, a curve fit will be performed.

Anodic polarization introduces "irreversible capacitance," i.e. the increase in capacitance during polarization does not completely die away. The effect is to shift the capacitance-time curve discontinuously to a higher value. Anomolous potential-time behavior has been observed at the higher current densities ($\sim 2 mA/cm^2$). This is in addition to the "superpolarization" mentioned in previous reports. This behavior will be investigated further.

STUDIES IN SPACECRAFT DYNAMICS

Introduction

Among the problems of spacecraft dynamics currently of major theoretical and practical interest are those relating to the nonrigid behavior of the vehicle and its internal constituents. There are many unsettled questions in this field, the answers to which will become increasingly important as spacecrafts increase in size and functional sophistication.

A study will be undertaken on certain aspects of spacecraft dynamics involving its nonrigid characteristics. The period for the study will be 1 June - 20 September, 1964. Actually, two distinct study efforts are included, representing two

approaches to this class of problems that might best be described as "general" and "specific." Together they provide an integrated research endeavor which should result in significant advances in the field.

Although more complete technical proposals for the two subsidiary studies are given below, it is appropriate to put them into perspective with one another. One, known as Study A, concerns general formulations of rotational dynamical descriptions for systems of partly rigid bodies which can be applied by appropriate specialization to any spacecraft. The other, Study B, concerns a more specific spacecraft type for which a suitable dynamical description can be developed directly and for which somewhat broader considerations are added, specifically those of external torques. These studies can be conducted relatively independently, but do have some cross-contributions. For example, Study A will substantiate portions of the dynamical development done in specific terms for Study B. Conversely, the latter, as a more extended development within a more restricted class of systems, should provide some practical guides for the general development (particularly as regards suitable approximations) in Study A.

Implications of the Study

The results of the study will have direct application to all future space vehicle dynamic analysis, particularly for the more sophisticated vehicles containing a crew and a

variety of non-rigid subsidiary parts. Applications will include such topics as stability in the presence of expected torque disturbances, control system design for non-rigid systems, structural design problems related to elastic waves and fluid motion, effects undesirable from a biological viewpoint which may arise from non-rigid behavior, and the like.

The proposed study actually is envisioned as a first step in a continuing program of basic investigations of space vehicle attitude dynamics. Ultimately it will be desirable to apply the descriptions developed herein to a broader class of cases of practical interest and to undertake more extensive studies on response to disturbances, stability, dynamical implications to vehicle design, and dynamical considerations related to control method or control parameter changes. A correct and convenient dynamical formulation for the rotational behavior of a space vehicle of very general type underlies all such contemplated advances. It is expected that longer range and perhaps more extensive support for future investigations along these lines will be sought from NASA or the Air Force after we are in a position to demonstrate that we have a sound foundation for the necessary dynamical equations and a formulation for the latter which is convenient in practical application.

In connection with both the proposed study and possible follow-on studies for which support will be sought elsewhere,

the educational implications should not be minimized. The study will involve only two graduate students directly because of its relatively small scale, but it is felt that the results we expect from this study will have sufficient novelty and practical interest that they will provide considerable material for future meaty theses. If supplementary support is obtained after the completion of the proposed study, both the direct involvement of graduate students and the generation of suitable thesis material should increase significantly.

TECHNICAL PROPOSAL, STUDY A

R. E. Roberson Account No. 448639

A satellite or space vehicle generally consists of a complicated assemblage of interconnected parts, some of which are rigid and some of which have fluid or elastic properties. The variety and complexity of internal parts which can move relative to the vehicle become especially great for more advanced space vehicles, such as the manned orbiting laboratories and similar vehicles now under consideration.

The dynamical descriptions of systems of material bodies in space take a somewhat different form than the dynamical descriptions of systems of bodies on the earth. When an internal body is moved relative to a space vehicle, the inertial reactions often are important in cases where they would be completely negligible -- at least in their

engineering affects -- if the system were on the earth and these reactions were masked by the presence of a system weight. The result is that many terms in the dynamical equations which normally can be discarded at once in terrestrial engineering practice must now be kept as an essential part of the description of the dynamical behavior of the space vehicle.

The dynamical description for the rotation of space vehicles, in the form of Euler-like scalar equations (generalized to account for the presence of subsidiary moving parts) has been developed at some length for the case of systems of rigid bodies. Unfortunately, similar progress has not been made on the dynamical description of systems which contain fluid inclusions and elastic members. A substantial body of literature on the problem of rotating fluid masses exists, of course, in connection with the classical problem of the figure of the earth. This literature is best summarized by Jardetsky (Theories of Figures of Celestial Bodies, Interscience, N. Y., 1958). But although there is some carryover from the dynamical formulations used to analyze that problem, it does not contribute as heavily as one might hope to the problem of nonrigid spacecraft. It does not include elastic considerations, nor does it hint at a proper extension to systems of bodies rather than a single body. In almost all other existing

literature on nonrigid bodies in rotation, the assumption is made that the body acts as a pure external driving force (i.e. a motion of the base) on the elastic or fluid members, neglecting the reaction of the motion of these members back on the motion of the supporting vehicle itself. This latter assumption is not at all correct for space vehicles.

A first portion of the total study is hereby proposed to develop a proper and useful description for the rotational dynamics of systems of partly rigid bodies, with specific reference to the bodies of this type encountered in astronautical applications.

Specifically, it is proposed in "Study A" to:

1. Define carefully the types of nonrigid parts to be included in the dynamic model;
2. Extend and generalize unpublished work by Dr. Roberson by adjoining to the ordinary differential equations which describe the rotational motion of the rigid parts of the system, a set of partial differential equations for the motion of the continuum;
3. Relate the boundary conditions of the partial differential equations to the motion of the rigid parts of the system, and in particular to the motion of the main vehicle structure;

4. Develop specialized forms of the resulting set of equations, e.g. linearized forms that apply to cases of practical astronautical interest, and to solve certain of the specialized cases and/or deduce certain properties thereof, such as stability. (Only a few illustrative cases would be carried this far during the proposed study, mainly as a test of the usefulness of the formulation which is developed for the dynamical description);
5. To conduct a rather extensive and quite meticulous survey of the classical literature of dynamics, with special attention to works which are not readily available (e.g. Euler's complete works) for obvious scholarly reasons.

TECHNICAL PROPOSAL, STUDY B

W. T. Thomson Account No. 448640

Future satellites, which will be assembled or erected after reaching orbit, will be designed to withstand the orbit environment in the deployed configuration which differs from the undeployed configuration during launch. Structural stiffness and strength need only be sufficient to withstand the very small loads occurring in orbit. Loads due to satellite rotation, to solar radiation pressure and to nonuniform

gravitation will be significant.

Nonuniform gravitation results from the inverse-square nature of the earth's field. The part of the satellite closest to the earth is attracted to it most strongly, producing moments on the satellites and forces within it. This principle is used to make a long thin satellite point vertically in orbit. Because large moments of inertia are required, satellite dimensions are large. Satellites of 60-foot-length (i.e. TRAAC) have been successfully stabilized whereas a 1000-foot satellite is presently under design by Goddard Space Flight Center.

Required strength and stiffness of any satellite are determined by the following criteria:

1. The structural natural frequencies must not be excited dangerously by the rigid-body motions.
2. Strength must be sufficient so that the rigid-body motions do not produce excessive loads.
3. Thermoelastic deformation due to solar heating must not produce excessive changes in the rigid-body attitude.
4. Elastic deformation under solar pressure, the earth's magnetic field and other external torques must not be excessive.

The problems described will be most significant in large unmanned satellites, particularly weather and communications

satellites, which are likely to be gravity-stabilized.

Most work on the structural dynamics of very flexible satellites has represented the satellite as two rigid bodies connected by a soft spring. General structural deformation has not been considered.

It is proposed to examine the structural dynamics of very flexible satellites in nonuniform gravitational fields. The following are analytical problems pertinent to satellite design. As many of these as time allows will be formulated and their solutions attempted:

1. A long, flexible satellite (idealized as a nonuniform beam) will be analyzed to determine strength and stiffness required to withstand rigid-body motions in orbit.

2. A gravity-stabilized satellite incorporating thermally sensitive inertia booms will be examined to determine the pointing errors due to thermal deformations.

3. The stiffening effects of nonuniform gravitation on a structure will be examined and related to an increase in load capability for some idealized satellite configurations.

4. As a system for damping gravity gradient oscillations, it has been proposed to deploy a long flexible string with internal damping from a satellite. The stability of such a device will be evaluated and if possible, an estimate will be made of the damping produced.

5. Most of the above work pertains to satellites which are gravity-stabilized. It is also proposed to examine the problem of gravity moments on a spin-stabilized satellite. Using the framework of the previous problems, an attempt will be made to evaluate the effect of nonuniform gravity on a slowly spinning flexible satellite, idealized as two rigid bodies connected by a spring, or as a flexible membrane. An extension of previous work in this area will be attempted.

6. It is possible that the problem of structural dynamics in nonuniform gravitational fields can be put in a general matrix form with new matrices representing the gravity forces. An attempt will be made to formulate this problem.

EFFECTS OF PRESSURE ON MAGNETIC INTERACTION

L. B. Robinson Account No. 448635

Mr. Swie-in-Tan has completed experiments measuring the effect of pressure on the Curie temperature of terbium, and the effect of pressure on both the Neèl point and the Curie temperature of dysprosium. Results will be submitted to the Physical Review or an equivalent journal.

FLUID MECHANICAL PROBLEMS OF LOW DENSITY GAS FLOWS

N. Rott
C. Y. Liu

Account No. 448632

The research on low density gas flow phenomena is conducted at both the continuum end and at the free molecular end of the flow spectrum.

Investigations at the continuum end involve research in second order boundary layer theory. A thesis has been completed by Leroy Devan in which second order effects are calculated based on a numerically given first order solution. (Mr. Devan's Ph.D. examination was given on May 12.) Dr. M. Oberai, who recently joined this research group, worked on the application of momentum integral methods to second order boundary layer theory.

At the free molecular end, research was directed toward the shock structure problem in gas mixtures. Dr. Liu is working on a report on the validity of Fick's Law of Diffusion. Dr. Oberai investigates the applicability of the Mott-Smith theory to gas mixtures.

MASS TRANSFER COEFFICIENT

A. R. Wazzan

Account No. 448637

A paper entitled "Skin Friction Measurement in Flat Plate Compressible Flow Using Mass Transfer Technique" has been

prepared on the results of this research. The abstract follows:

Abstract

A mass transfer method developed by Smith for measurement of local wall shear stress in incompressible flow is extended to compressible flow. The model surface is coated with a thin liquid film and the evaporation rate is determined from the rate of change of film thickness using light interference fringes. The method is applied to wall shear stress measurements in flat plate flow. Measurements of distribution of local shear stress over the plate relative to the value at the leading edge in laminar flow at Mach numbers 2.72 and 1.58 are given. It is found that the local shear stress C_f in laminar compressible flow over flat plate with mass transfer is lower than the corresponding value in the absence of mass transfer. C_f is found to vary inversely with $X^{3/2}$.

NEW RESEARCH STAFF - ENGINEERING

NASA 237-62 funds were made available to the Department of Engineering to provide partial support to five temporary research appointments in space-related areas. Although some of the appointments have teaching titles, only their research activities are supported from NASA funds.

C. Helstrom - During both the Fall and Spring semesters Dr. Helstrom taught Engineering 186a, "Introduction to the Theory of Detection", and shared responsibility with Professor Balakrishnan for the Communication Theory Seminar, Engineering 298. In the Fall semester he presented at this seminar a series of lectures on the theory of continuous Markov processes, on the first-passage-time problem and related problems for stochastic processes, and on the sequential detection of signals. These lectures lasted for about ten weeks; during the rest of the term the seminar heard reports by graduate students in communication theory. The Spring semester of the seminar was taken up with lectures and reports by students and faculty of the Information Systems Division. During three of the meetings, Dr. Helstrom talked about the detection of optical signals and about some of the statistical properties of natural light. In May he gave six lectures on Markov processes to the students in Engineering 286c, "Mean-Square Optimization Methods".

Throughout the year he has continued his research on the statistical properties of radiation and on the detection of radiative signals. A paper entitled "The Detection and Resolution of Optical Signals" was written and has been accepted for publication in the I.E.E.E. Transactions on Information Theory. This work applies the methods of the statistical theory of signal detection to finding the optimum systems for detecting radiative signals and to studying

the limitations on such detection imposed by the quantal nature of light and the stochastic properties of the ambient radiation field.

During the Spring, Dr. Helstrom has been writing two chapters of a book on communication theory to be edited by Professor Balakrishnan. One chapter deals with Markov processes, the other with sequential detection. He has taken advantage of UCLA's excellent library to begin a study of the foundations of probability and statistics by reading a number of works on that subject.

On February 6, 1964, Dr. Helstrom spoke to the Los Angeles section of the I.E.E.E. Professional Group on Information Theory about the scattering and detection of shortwave radar echoes, and on May 12 he talked to an electrical engineering seminar at Cal Tech on the detection of optical signals. During the year he has reviewed five papers for the I.E.E.E. Transactions on Information Theory.

W. Jost - During the period of February through April, 1964, Professor Wilhelm Jost of the Institut für Physikalische Chemie der Universität Göttingen was with the Department of Engineering. Many members of the faculty and staff and graduate students were aided in the fields of chemical kinetics, solid state reactions, and chemical thermodynamics on a consulting basis by Dr. Jost, who is an internationally

known authority in these fields. He worked closely with Professors Knapp and Kurtz in high temperature calorimetry and measurement involving heats of mixing of melts, with Professor Perrine in chemical kinetics, and with Professor Sines in diffusion in materials.

Dr. Jost also presented a series of weekly seminars on diffusion in solids, reaction kinetics and fast gas reactions. An outline of topics discussed in the seminars follows:

1. Diffusion leading to equalization of concentration differences.
   More precise formulation: valid for sufficiently ideal isothermal systems consisting of a single phase. Exceptions especially with multicomponent and multiphase systems.
   Diffusion as random walk process. Formal treatment of diffusion processes. Examples of diffusion with gases, liquids and solids.

2. Formal description of diffusion processes and methods for measuring diffusion rates. Diffusion experiments with $dD/dc \neq 0$. Diffusion in anisotropic systems (especially noncubic cyrstals).
   Some general results for systems with concentration-dependent diffusion coefficient. Experimental

methods and methods of evaluation.
Problem of boundary condition with condensed phases.
Diffusion and convection.
Flame as example.

3. The disordered solid. Diffusion and ionic conduction in solids. Survey of experiments. Diffusion in molecular solids, e.g., H_2, solid rare gases. Permeation. Surface reactions of metals with sulfur, oxygen, halogens. Other reactions between solids. Types of disorders. Thermodynamic treatment of disorders. Experimental tests. Energies of disorders.

4. Diffusion and ionic conduction in ionic crystals, continued. Electrical transport of matter in metals. Diffusion in metals. Pressure effects in ionic crystals and metals. Kirkendall effect in metals. Its pressure dependence compared with that of diffusion.

5. Diffusion in liquids, especially in ternary liquid systems.

6. <u>Reactions in adiabatically compressed gas mixtures</u>. Reaction times between 1 and 100 m secs. Analysis by pressure recording, spectroscopy, photography, gas sampling and analysis. Method applied primarily

to hydrogen-air mixtures.

7. Reactions in flames. Methods of analysis: local temperature measurements by independent methods; gas analysis; absorption and emission spectroscopy; mass spectrometry. Pressure dependence investigated between ca. 1/150 to 20 atmospheres. Hydrogen-oxygen, carbon monoxide-oxygen, hydrocarbons-oxygen; soot formation and formation of polyacetylenes in acetylene oxygen flames. Effect of additives.

8. Reactions in detonations. Reaction times between 0.2 and 10μ seconds. Spinning detonations of carbon-monoxide oxygen; hydrogen-oxygen; hydrocarbons-oxygen; hydroxylamine-dinitrogen monoxide. Optical methods, Schlieren method.

9. Reactions in shock waves. Reaction times between 1 and 250μ seconds. Decomposition reactions of small molecules, N_2H_4; NH_3; N_2O; CO_2.

10. Aspects of flame theory. Thermal theory. Theory of strictly oval flames. Simplified treatment by Feldon Zeldovitch. Application to several types of reactions.

D. Medved - A considerable advance of technological competence and capabilities in the Solid State Electronics area was brought about by a highly enthusiastic and hard-

working group of senior students in the design activities of the Senior Design Group 104C,D. Utilizing the development of an injunction luminescent semiconductor diode communication system as a central motivating force, Dr. Medved's group was able to establish within the framework of the solid state electronics laboratory the competence to start with the raw semiconductor material, such as silicon or gallium arsenide, and proceed through the entire sequence of junction fabrication techniques, diagnostics and diode mounting to a finished device. In particular, the group can now carry out junction formation by means of diffusion in semiconductors such as germanium, silicon and the intermetallic compounds. They are also able to evaluate the nature and depth of the junctions formed by the use of the hot probe and angle section and staining techniques. The junctions can be cleaved, polished, mesas etched to produce diodes of sufficiently small size for use in injection luminescence and as possible laser sources. This capability has been built up with a minimum of expense (less than $400) and a great deal of hard work on the part of the students. It is Dr. Medved's recommendation that an activity of this nature should be encouraged and continued in the forthcoming Fall and Spring semesters. Continuation of a program of this nature for another four to eight months under appropriate guidance could easily result in publishable advances in the state of

the art in both semiconductor electronics and optical communication systems.

Research proposals were submitted to NSF and NASA on the study of electron emission from solids. A preliminary inquiry from NSF has indicated a definite interest on their part. It is anticipated, however, that funds for this work will not be forthcoming from these agencies until the fall of 1964. In the meantime, seeding funds have been requested from the Space Science Center at UCLA.

A. Papoulis has been appointed Visiting Professor and Research Engineer for the academic year 1964-65. He received his M.S. in Electrical Engineering, and the M.A. and Ph.D. in Mathematics from the University of Pennsylvania after completing his undergraduate work in engineering at the Polytechnic Institute of Athens, Greece. He is presently a Professor of Electrical Engineering at the Polytechnic Institute of Brooklyn where he is an outstanding faculty member. He is highly regarded for his broad intellectual stature and his outstanding contributions in circuit theory. He has recently published a book on "Fourier Integrals" which represents a major contribution to the field. He is recognized as an outstanding contributor in the area of network synthesis and linear systems analysis.

R. Stampfl has been appointed Lecturer and Research Engineer for the academic year 1964-65. He received the B.S., M.S., and Ph.D. degrees in Electrical Engineering from the Institute of Technology in Vienna. Since 1959 he has been with the NASA Goddard Space Flight Center, where he is presently Head, Instrumentation Branch. Dr. Stampfl has participated in several short courses on Space Communications at UCLA. It is anticipated that his appointment will have great impact on the research programs in the communications systems area because of his experience in the development and design of instrumentation.

PROBLEMS RELATING TO PLANNING AND CONTROL IN THE MANAGEMENT OF SCIENTIFIC RESEARCH AND DEVELOPMENT - NsG 237-62 Supp. 2

G. A. Steiner

This grant was made to support the study and analysis of problems relating to planning and control in the management of scientific research and development. One of the unique provisions of the grant is that all study proposals must be approved by NASA. While the grant was made July 1, 1963, individual proposals have been approved only recently. The net result is that intensive investigation for most of the projects first began during the summer of 1964. Following are the major projects now under way and the principal investigators. Professor George A. Steiner is over-all project director.

Managerial Methods to Reduce Time and Costs of Research in the Stages of Development, Test and Pre-Production

G. A. Steiner

There are a number of different parts to this project. A few directors of large projects in the United States and foreign countries have been exceptionally successful in reducing time and cost to prototype substantially below that usually experienced. These directors have developed managerial practices and policies, working conditions, employment methods, and organization somewhat different than generally permitted in and practiced by prime con-

tractors. This study will examine several of these projects to develop a managerial model which may be used by procurement agencies to permit the type of practices which can lead to great savings in time and cost while assuring suitable controls to get required quality.

There are also sub-parts of this project. One concerns the development of a managerial model which will simplify and improve subcontracting procedures. Another relates to the development of principles to relate the scope, depth, and application of PERT/Cost to program needs. Several other subprograms are under discussion but assignments have not been made.

Improving the Productivity of Research Scientists

C. O'Donnell

There is a need to find out just how enterprise managers maximize the productivity of research scientists. Some important parts of this problem lie in the border area of developing the manager-scientist.

The initial selection process requires study. Do the criteria that have been developed for the selection of scientific personnel meet the needs of the technical organization? Some useful criteria have been developed for the selection of managerial personnel; to what extent, if at all, are these criteria applicable to the selection of the

scientists who increasingly are called upon to participate in managerial decisions and activities?

This emergent role of the scientist-manager will be explored. There are numerous instances of outstanding scientists who have served, apparently with success, as managers and top administrators. There are probably less well known instances of failure of scientists in the managerial role. Studies and useful case histories are needed to help serve as a basis for the improvement of the management, and hence the productivity, of scientific personnel.

In this connection the questions will be raised, and answers sought: Is the management of scientific personnel a different problem than the management of other types of personnel? How do the aerospace companies meet this problem? Is their approach different from that of companies in other industries?

An element of the important role of the scientist-manager is the problem of integrating the organizational efforts of the diverse disciplines involved in the execution of complex programs. It is fairly well recognized that this problem involves the managerial functions of planning, organizing, staffing, and controlling. Faced with the situation that demands that he be a "generalist," what are the difficulties that the scientist encounters as he makes this transition to the managerial role? If this is in fact

a problem, a failure of the scientist to adapt himself to this administrative role could cause serious difficulties in the effort to achieve organizational goals. This research would explore this area and seek an answer to the question: How well does the scientist adapt to the managerial role? And, what can be done to enhance this transition?

The improvement of productivity as a managerial objective is closely allied to the problem of control of scientific activities. Almost by definition, however, scientific activity defies quantification. Yet the essence of control is measurement. With the stress of scientific operations on time and budget, what is the experience of managerial control in its application to the scientific field? The proposed research would involve the experience that is available among the firms in the Southern California area engaged in this field of activity.

The project leader will direct research writers (including Assistant Professors) in the development of information concerning the management of scientists employed in the aerospace industry. Firms will be selected in the aerospace industry that are located in Southern California. An adequate sample of both managers and scientists will be interviewed in depth.

Generally speaking, the focus of this research will be upon the management of scientists and the training of scien-

tists for management assignments. The experience of enterprises in handling these issues will hopefully provide us with a basis for generalizations which may be applied within the NASA operation.

Measures to Improve Organizational Health and Managerial Effectiveness

R. Tannenbaum
F. Massarik

The following is a brief statement of investigations planned:

1. The Socio-Psychological Correlates of Organizational Health

   Available work aimed at development of a theory of organizational health will be continued and amplified. It is the purpose of this theory to state rigorously the human and socio-technical conditions and their interrelations, characterizing organizations which exceed levels of mere routine performance for a considerable period of time. Our interest is in organizations which are able to change and grow under a variety of external social and economic circumstances (such as changes in product demand, economic climate, etc.), and which are successful to an above-average extent in meeting the social and psychological growth needs of their employees.

The "ideal type" of such a healthy organization will be used as an analytic tool in empirical studies of a variety of existing firms, particularly in firms which intuitively appear to rank high in organizational health. The behaviors of managerial and non-managerial personnel and the formal and informal social structures of these firms will be investigated. Special emphasis will be placed on the study of patterns of planning and control characterizing these more-or-less healthy firms.

Systematic interviewing and testing programs will probe unconscious as well as conscious aspects of organizational and managerial behaviour. These programs will be augmented by participant and non-participant observation over an extended time period. The role of organizational activities designed to bring about change will be considered both as correlate and symptom of the organization's growth potential.

Simulations of healthy organization forms will be carried out in the Behavioral Science Research and Training Laboratory at UCLA. Efforts will be made to establish consistencies of "health" appearing both in the Laboratory and in real-life enterprises.

2. The Impact of Managers' Time Perspectives on Planning

Considerable bibliographic and some empirical work has been completed concerning the feelings of managers, scientists and engineers with respect to time--time as a source of concern in their daily lives, their views of "time yet left to live," response to time pressure in work, etc. This inquiry will deal specifically with the attitudes toward time as they affect the planning process. Studies will be conducted probing factors affecting the establishment of various planning horizons by managers at different levels in the organizational hierarchy. The extent to which "time left in the working career" (e.g., prior to retirement) influences long-range planning decisions of top managerial personnel will be of particular interest. Various patterns of attitude and feeling toward time will be correlated with actual planning decisions then of record.

Deeply-probing interviews and projective measures will be used in the study of the manager's time perspectives, while company records and publicly-announced planning commitments will provide measures of the planning function. The human aspects of the planning process itself necessarily will be a key focus of this research.

3. Communication and Influence Networks Diagnostic of Managerial Effectiveness

Building on prior work of the Human Relations Research Group, as published in Leadership and Organization (McGraw-Hill, 1961), and on current theories of organizational functioning, a series of studies will be undertaken to develop a systematic classification of influence and communication patterns which, under varied external circumstances (such as differential time pressures, work-group sizes, etc.) are predictive of managerial effectiveness, and organizational health. Face-to-face work groups, sections, divisions and departments of several firms will be investigated, tracing flows of communication and influence horizontally, upward and downward along hierarchical lines. It is hypothesized that particularly freely-flowing upward communication and influence will relate to the health and effectiveness criteria. Analogous studies will be conducted under the controlled conditions in the Behavioral Science Laboratory.

Evaluation and Selection of Advanced Studies

L. G. Strasburg

The high cost of research and development in both the government sector (defense, space systems) and the private

industrial sector (new products) has created the need for more advanced study efforts and expanded their scope to considerations of the following:

- technical characteristics of proposed R & D activities
- applicability of R & D activities to ultimate objectives
- practical constraints on the conduct of these activities, such as schedule
- resources necessary for implementation of proposed R & D activities
- relative value in relation to other activities being considered
- risks inherent in such activities

In short, the results of advanced studies are expected materially to contribute to the decision process leading to initiation of R & D activities.

The Department of Defense has codified this use of advanced studies into the Program Definition Phase of weapons systems acquisitions, and NASA is relying heavily on studies to probe mission objectives, mission profile and flight sequence, reliability, cost estimating methodology, and mission optimization techniques. These examples indicate the growing utilization of advanced studies not only for information for decision, but also for the generation of the techniques of decision making. Clearly, with such a trend come concomitant pressures for more elaborate,

and costly studies -- themselves requiring a process of evaluation and selection before initiation. Particularly in the area of Government research and development the following factors contribute to the growing interest and concern, in the award and conduct of advanced studies:

- the promise of "follow-on" R & D and limited production stemming from advanced or conceptual studies
- the propensity of Government agencies to award studies on a sole-source or unsolicited proposal basis, thereby minimizing competition
- the reserve of highly-trained research and study personnel maintained on the staffs of large technologically-oriented companies, who retain these people to attract business, but must find study contracts to support them
- the reduced number of defense or space systems contracts, shifting the arena of competition from systems contract bidding to the generation of the requirements for a particular system, so as to be in "on the ground floor"

These factors also imply increased scrutiny of the process of evaluation and selection of these study contracts. Consistent policies and definitive requirements must regulate the initiation of advanced study contracts so as to maximize returns. The results, of course, cannot be prescribed, but the approach can be structured so as to introduce competition and control over the eventual study conduct.

It is to the fundamental approach to evaluation and selection of these advanced studies that this investigation

will be directed.

There will be two distinct, but related, aspects of the investigation:

- the evaluation process - determination of value systems against which the objectives and requirements of the study may be compared; construction of a rationale for study proposal solicitation.
- the selection process - establishment of criteria for comparison of competing study proposals, study of the dynamics of selection, including criteria weighting, procedures, committee or board utilization

The data for this investigation will be gathered from local aerospace companies, organizations such as Rand and SDC, and Governmental agencies such as the Air Force Space Systems Division.

The Economics of Performing Engineering Tasks

J. M. English

There is a need to relate expected economic benefit to the cost incurred to achieve it. This may be particularly significant in relation to extent of analysis now done to justify predicted performance of a system or subsystem. An attempt will be made to develop cost as a function of extent of analysis and relate it to a function for either reliability or confidence level. The management factors which may influence action toward optimizing analytical effort will be studied.

The first step (during the first year of study) will be to take an elemental example (e.g., design of a beam with a load on it) with the amount of information limited. A mathematical model will be developed from which one can calculate the increase in reliability (as a function of new information) by further testing or analysis.

A later step will be to generalize from the basic model and try to apply it, with appropriate modifications, to more complex engineering systems. This may be accomplished in a second year of study.

A paper entitled "Understanding the Design Process" has been published by J. M. English, Department of Engineering, Report No. 64-67, UCLA, January 1964.

Technology Transfer Process

G. A. Steiner
W. R. Ryan

Two projects have been started in this area. First, a program to permit the support of industry in improving the transfer process has been developed and is now in process of application. Second, a project has begun to monitor and evaluate, over time, flows of information important in the transfer process. A group of new metal discoveries is the specific subject of study.

VISITING SCIENTISTS

Since the report period covers the end of the spring semester and the summer vacation, there were no lectures or seminars other than informal talks given by the visiting scientists.

Aharon Nir - Senior Scientist, Isotope Department, The Weizmann Institute of Science, Rehovoth, Israel

Dr. Nir has been investigating the feasibility of detection of short-lived isotopes (hours to days) in the solar proton irradiated area of the upper atmosphere. Analysis of several isotopes produced by solar flare protons and particles could supplement the information on the history of the flare and its energy spectrum. Several papers in collaboration with E. J. Flamm and R. E. Lingenfelter are in preparation and will be covered in the next report.

P. H. Ribbe - Assistant Professor of Geology, University of Chicago

Dr. Ribbe's research to date has been concerned with a literature survey and study of certain diamond-bearing rocks of South Africa. Thirty cognate xenoliths collected by Professor G. C. Kennedy from kimberlite pipes located at Roberts Victor, Du Toitspan, Bultfontein, Wesselton, and other mines have been sectioned and subjected to a cursory petrographic investigation. These rocks are mainly eclogites

and pyroxenites in various states of alteration. Some give evidence of having experienced considerable stress; grains show undulatory extinction and grain boundaries are frequently crushed into fine fragments.

These rocks are thought to be representative of the upper mantle, having been transported from great depths by the kimberlite "magma". As such they are of great value in furthering our understanding of the earth and other planets. We plan to study them in great detail and in the near future will prepare specimens for an extensive analysis with the electron-microprobe.

Edward Teller - Professor-at-Large of Physics, University of California

Dr. Teller visited the Space Science Center in March, May, and August. During his visits, he consulted with faculty members, research staff, and graduate students in the physical sciences and engineering. In August he lectured to the Summer Institute in Planetary Physics on "Explosions in Massive Stars". The lecture was attended by many other students from UCLA.

B I B L I O G R A P H Y

PHYSICAL SCIENCES

Aller, L. H., The spectrum of NGC 7027, Astrophys. J., Nov. 1963.

Aller, L. H., Spectrophotometry of 14 Southern nebulae, No. 11, IAU/URSI Symposium No. 20.

Aller, L. H., et al., Energy distribution in globular star clusters, No. 73, IAU/URSI Symposium No. 20.

Aller, L. H., and H. R. Dickel, et al., Photoelectric spectrophotometry of emission nebulosities in the Magellanic clouds, No. 63, IAU/URSI Symposium No. 20.

Aller, L. H., and W. P. Bidelman, The Manganese star 53 Tauri, Astrophys. J., Jan. 1964.

Aller, L. H., A. Cowley, and T. Dunham, Jr., The Hydrogen to Helium ratio in HD 96446, Publ. A. S. P., Oct. 1963.

Aller, L. H., and J. B. Kaler, Spectrophotometric studies of gaseous nebulae I. The double-ring planetary NGC 7009, Astrophys. J., May 1964.

Aller, L. H., B. J. O'Mara, and S. Little, The abundance of Iron and Silicon in the sun, Proc. Natl. Acad. Sci. U.S., 1238-1243, June 1964.

Aller, L. H., and D. J. Faulkner, Spectrophotometry of the Wolf-Rayet star γ^2 Velorum, Astrophys. J., July 1964.

Aller, L. H., and J. B. Kaler, Spectrophotometric studies of gaseous nebulae II. The moderate-excitation planetaries NGC 6572 and IC 4997, Astrophys. J., (in press).

Aller, L. H., The abundance of elements in the solar atmosphere, (in press).

Bömmel, H. E., W. F. Libby, B. R. Tittman, and A. J. Darnell, Superconductivity in the artificial metals: metallic Indium Antimonide, the Indium Antimonide, Tin alloys, and metallic Indium Telluride, accepted for publication in Phys. Rev., August 31, 1964.

Caputo, M., Some space gravity formulas and the dimensions and the mass of the earth, PAGEOPH, 57, 66-82, 1964/1.

Coleman, P. J., Jr., L. Davis, Jr., E. J. Smith, and C. P. Sonett, Interplanetary magnetic fields: Preliminary observations from Mariner II, Science, 138, No. 3545, 1962.

Coleman, P. J., Jr., E. J. Smith, L. Davis, Jr., and C. P. Sonett, Magnetic fields measured in the vicinity of Venus: Preliminary observations from Mariner II, Science, 139, No. 3558, 1963.

Coleman, P. J., Jr., Characteristics of the region of interaction between the interplanetary plasma and the geomagnetic field: Pioneer 5, J. Geophys. Res., 69, No. 15, 1964 (in press).

Coleman, P. J., Jr., C. P. Sonett, D. S. Colburn, L. Davis, Jr., and E. J. Smith, Evidence for a collision-free magneto-hydrodynamic shock in interplanetary space, submitted to Phys. Rev. Letters, June 1964.

Coleman, P. J., Jr., E. J. Smith, L. Davis, Jr., and C. P. Sonett, Interplanetary magnetic field measurements: the Mariner II magnetometer experiment, Proc. of the Conference on the Solar Wind, Pasadena, Calif., April 1964 (in press).

Flamm, E. J., and R. E. Lingenfelter, Neutron and proton dosages in the upper atmosphere from solar flare radiation, Science, 144, 3626, June 26, 1964.

Hyder, C. L., (1964a), Magnetic fields in the loop prominence of 16 March 1964, Astrophys. J., 140, (Letter to the Editor).

Hyder, C. L., (1964b), The polarization of emission lines in astronomy IV. Prominence emission line polarization and prominence magnetic fields, submitted to Astrophys. J. in July, 1964.

Hyder, C. L., (1964c), The polarization of emission lines in astronomy III. The polarization of coronal emission lines, Astrophys. J. (in press).

Hyder, C. L., (1964d), The polar crown of filaments and the sun's polar magnetic fields, submitted to Astrophys. J. in July, 1964.

Hyder, C. L., and J. W. Warwick, (1964c), Random microscopic magnetic fields in a plasma, Astrophys J., (in press).

Karras, T., Breakdown in a nonlinear field, Ph.D. Thesis, UCLA, 1964.

Karras, T., and E. Lindman, RF breakdown in a DC parabolic potential field, submitted to J. Appl. Phys.

Kaula, W. M., Introduction to Space Science, edited by W. N. Hess, Academic Press Inc., New York, to be published in Spring, 1965.

Kaula, W. M., Tidal dissipation by solid friction and the resulting orbital evolution, accepted for publication in Review of Geophysics.

Lindman, E., RF breakdown in a linear electric field, Ph.D. Thesis, UCLA, June 1964.

Lingenfelter, R. E., and E. J. Flamm, Production of carbon 14 by solar protons, J. Atmospheric Sci., 21, 134, 1964.

Lingenfelter, R. E., and E. J. Flamm, Neutron leakage flux from interactions of solar protons in the atmosphere, J. Geophys. Res., 69, 2199, 1964.

Lingenfelter, R. E., and E. J. Flamm, Solar neutrons and the earth's radiation belts, Science, 144, 292, 1964.

ENGINEERING

Baker, R. M. L., Jr., and K. Forster, Orbit determination by linearized drag analysis, Proc. A.I.A.A. Meeting, Yale University, August 1963.

Devan, L., and M. Oberai, Approximate solution of second-order boundary layer equations, I.A.A.A. Journal (in press).

Devan, L., Second-order incompressible laminar boundary layer development on a two-dimensional semi-infinite body, Ph.D. Thesis, UCLA, June 1964.

Forster, K., Satellite dynamics for small eccentricity including drag and thrust, American Institute of Aeronautics and Astronautics Journal, 1, 1963.

Frederking, T. H. K., Stability of film boiling two-phase flow in cryogenic systems, Proc. Am. Inst. Chem. Engrs. Meeting, Memphis, Tenn., February 1964.

Habib, J. N., General instability of structures, Ph.D. Thesis, UCLA, June 1964.

Helstrom, C. W., Scattering from a cylinder coated with a dielectric material, Proc. Symposium on Electromagnetic Theory and Antennas, 1, 133-144, June 1962.

Helstrom, C. W., The distribution of photoelectric counts from partially polarized Gaussian light, Proc. Phys. Soc. London, 83, 777-782, May 1964.

Helstrom, C. W., The detection and resolution of optical signals, accepted for publication in the I.E.E.E. Trans. on Info. Theory.

Hurty, W. C., On the dynamic analysis of structural systems using component modes, Proc. A.I.A.A. Meeting, Washington, D.C., July 1964.

Karplus, W. J., Hybrid computation techniques for the solution of engineering problems, Bull. International Computation Center, 3, No. 1, 22-29, 1964.

Karplus, W. J., A transfluxer analog memory using frequency modulation, to be presented at the Fall Joint Computer Conference, San Francisco, Calif., October, 1964.

Knuth, E. L., Status report on development of a high-speed high-intensity molecular beam, Report No. 63-30, UCLA Dept. of Engineering, 1963.

Lin, T. H., Relief of residual stresses by localized heated patterns, Journal of Engineering Mechanics, 90 EM2, 87-110, 1964.

Lin, T. H., and J. Gnoung, Bending of rectangular plates with non-linear creep, accepted for publication in International Journal of Mechanical Sciences.

Medved, D. B., On the formation of satellite electron sheaths resulting from secondary emission and photo effects, a chapter from the textbook Interactions of Satellites with Ionized Atmosphere, Pergamon Press, 1964.

Medved, D. B., Satellite sheath dynamics, accepted for publication in Phys. Fluids.

Medved, D. B., Electron emission from solids resulting from ion and atom impact, Advances in Electronics and Electron Physics, 21.

Medved, D. B., An Introduction to Physical and Semiconductor Electronics, submitted for publication on June 30, 1964.

Nobe, K., Transient polarization methods in corrosion, 20th NACE Conference Educational Lectures, Part II, 1964.

Nobe, K., Potentiostatic polarization of Iron in H_2SO_4 - Effect of Chloride ion, 20th NACE Conference Educational Lectures, Part II, 1964.

Robinson, L. B., Onsager phenomenological coefficient for a weakly-ionized Cesium plasma, Phys. Fluids, 6, No. 11, 1578-1580, 1963.

Robinson, L. B., Effect of pressure on the Curie temperature of rare-earth metals. I. Gadolinium, Phys. Rev., 134, No. 1A, A187-A192, 1964.

Rott, N., On the pressure induced by the boundary layer on a flat plate in shear flow, J. Fluid Mech., 19, 1-10, 1964.

Wazzan, A. R., Friction measurement in flat plate compressible flow using mass transfer technique, submitted to J. Appl. Phys.

BIOLOGICAL SCIENCES

Carterette, E. C., and M. P. Friedman, Detection of Markovian sequences of signals, Proc. Accoust. Soc. of America, May, 1964.

Hamner, K. C., B. H. Carpenter, and T. Hoshizaki, The interaction of plant hormones and rotation around a horizontal axis on the growth and flowering of Xanthium Pensylvanicum (in press).

Hamner, K. C., and T. Hoshizaki, Circadian leaf movements; persistence in bean plants grown in continuous high intensity light (in press).

Hamner, K. C., and A. Takimoto, The effect of temperature and preconditioning on photoperiodic response of Pharbitis nil, Plant Physiology, November 1964 (in press).

Hamner, K. C., and M. W. Coulter, Photoperiodic flowering response of Biloxi Soybean in 72 hour cycles, Plant Physiology (in press).

Hamner, K. C., and A. Takimoto, Photoperiodism and circadian rhythms, The Amer. Naturalist, (in press).

Hoshizaki, T., and M. W. Coulter, A stem bending response of Perilla crispa to horizontal rotation, Internat. Biol. Congress, August 1964.